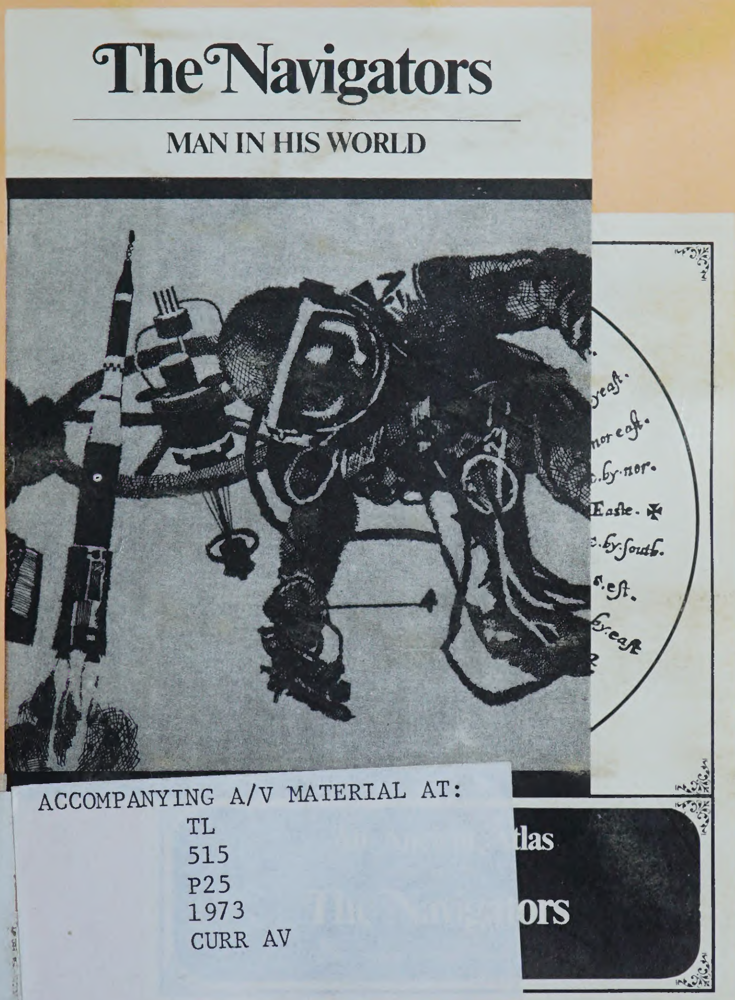
Teachers' Guide

The Navigators



MAN IN HIS WORLD

Curric

Teachers' Guide
The Navigators

Fitzhenry & Whiteside Limited

OBJECTIVES

For *The Navigators,* the authors had five main concepts in mind as they chose and assembled material. If the teacher remembers these, teaching with *The Navigators* will be enjoyable and profitable.

CONCEPTS

1. Man has always felt a need to travel and to trade. There is a relationship between trade and prosperity, indicated by the establishment of empires and the wealth of kings.
2. As man grew more venturesome, he needed a vehicle in which to journey.
3. As man travelled greater distances, at greater speeds, in a variety of directions, it became imperative that he develop navigational skills and ways of recording information about navigation.
4. New journeys of greater distances meant the creation of new life-support systems.
5. As man's technology was perfected, he seemed to acquire ever-increasing control over his environment. At what cost this control has been secured is worthy of consideration.

Students should be led to uncover these ideas. They should come to a realization of concepts rather than be told the concepts. If, after investigation, the student cannot arrive at one of the ideas listed above, the teacher may at that time choose to explain.

OUTLINE

THE NEW OCEAN

National Geographic has issued a record entitled *Sounds of the Space Age from Sputnik to Lunar Landing,* narrated by Colonel Frank Borman, U.S.A.F. astronaut. It is suggested that this recording, *in part,* be played to the class. It will gain their attention and arouse interest. Their ability to recall information of significance can be tested by asking them to make a record of what was said concerning: time, distance, direction, speed, craft.

From this moment of introduction on, whether it is by tape, record, film or reading *The Navigators,* pages 3-5, the students must be alerted to identify certain key concepts. Concern for questions of time, distance, direction and speed is necessary to navigate successfully in outer space. Indeed, it is necessary if man is to navigate in any space, large or small, in land, water or air.

It is imperative that measurements for determining *time, distance, direction* and *speed* be discussed. The student must identify the units that are used, the words that are used, the accuracy that is required. This is the right time for the teacher to examine the relationships between

time and direction = distance
distance and time = speed

These relationships, between *time, distance, speed* and *direction,* make up the conceptual focus of the whole book. They are applicable throughout all time and space.

The authors begin with a complicated example – a space trip. The many variables make it difficult for most people to understand, but the material is of contemporary interest and useful for identifying the main ideas to be pursued. If these ideas are applied to the simple, concrete examples to ensure understanding, the class may come back to the astronauts and reapply their understanding. These first three pages, with the excerpts from Apollo 8's log, are meant as an exercise to introduce and make familiar the necessities of travel.

It is important that the teacher encourage the students to keep track of the following factors when they are mentioned in the book, recordings, or films.

TIME – SPEED – LOCATION – DIRECTION – CRAFT – ENVIRONMENT – NAVIGATIONAL AIDS

Students should try to explain why keeping a record of these ideas is important, as well as the significance of each item in making a journey.

PAGES 4 – 5

The diagram is useful in explaining the intricacies of space travel, for example, the difficulty of aiming at where something *will* be. (This is what the astronauts must do – intercept the moon on its revolution about the earth.) Students should consider what advances in man's understanding of his environment were necessary before such a trip could be taken. In order to emphasize the difficulty of such a task, blindfold a student, turn him around a few times, then ask him to intercept someone who has been moving across the room. (NOTE: DID YOU KNOW? number 4 on page 7.)

PAGE 6

The questions here relate to the diagram. Questions 1 and 2 allow students to indicate their ideas and understandings about travel, scale, and problems of simple navigation. The teacher should accept any answer that the student can support with reasonable evidence. Remember, *any answer* which is rational is acceptable. This exercise may be too simple for some students, and can be regarded as optional.

PAGE 7 THINGS TO DO

(A) Stress should be placed on indicating the many reasonable answers that could be given, depending on the criteria a student wishes to establish regarding

1. The current (with or against?)
2. The water (rough or smooth?)
3. The rower (a professional or a small, weak man?)
4. The wind (blowing? which way?)

The emphasis must be placed on the possible variables, on the importance of asking good questions rather than giving answers.

(B) Lunar gravity is 1/6 that of the earth. Gravity is the pull imparted by a planet on bodies near or on that planet.

(C) After the Apollo leaves Earth, its speed gradually decreases from an escape velocity of 25,200 mph to 2,223 mph immediately before lunar orbit. Due to the pull of the moon's gravity, the speed will then increase to approximately 5,400 mph. This is the sign the student would mention. Note: all the speeds mentioned are found in the DID YOU KNOW? section on the same page.

Exercises 2 and 3 involve role-playing. Strict supervision to avoid horse-play will not restrict enjoyment or learning. Have the students suggest other exercises to emphasize points being considered.

PAGE 8

Consideration of communications is vital if man is to be successful in travelling in great numbers, for great distances, at great speeds, at great risk and considerable cost. Students should recognize the importance of an accurate language that affords little if any opportunity for confusion. They might consider Morse code and other special ways of communicating ideas. A whole new language of space has been developed. Students should try to discover the meaning of such terms as

Burn – a period of thrust in a rocket vehicle
Complex – entire area of launch site
G – force equal to Earth gravity
Hold – to halt a countdown
No Go – inability to proceed with mission

PAGE 9 – Question 2

Without an exact time by which to measure every event that requires a change in direction or speed of the craft, the flight would soon be in difficulty.

PAGE 10

After this introduction to space travel, details mentioned on pages 3-5 can be considered. Students can be asked such questions as:

How many stories would a 363′ high building have?
What does your father's car produce in pounds of thrust?
Why is the craft which houses the astronauts set on top of a series of parts which are discarded?

Notice that the book should be used in many ways, straight through from page 3 to 63, for instance, or sometimes backwards, for example, from page 10 back to page 3.

The emphasis on page 10 is on living in the *spacecraft* or *capsule*, which is small, sealed and pressurized to support living things in space.

Apollo's food supply must be rich in vitamin and calorie values, light in weight and, where possible, compressed. Students could be asked why. Each man is provided with dehydrated juices and bite-size food requiring no refrigeration, eaten under weightless conditions.

A typical day, with four meals, might include spaghetti and meat sauce, sausage patties, tuna salad, beef pot-roast, chicken bits, toast squares, and orange-grapefruit juice (to which a few ounces of water are added). How is this food eaten?

Apollo carries only a small amount of drinking water. Most of what is required is produced

as a by-product of the electric fuel cells. When used for drinking, the water is at 50° F; when used for reconstitution of dehydrated food it is at 150° F. How do the astronauts drink when in their space suits?

PAGE 11 PROBLEMS OF NAVIGATION

1. (a) Approx. 14 hours
   (b) Approx. 4 hours
   (c) Approx 2 hours
2, 3. The spacecraft would miss the moon.
4. The computer gives this information to the spacecraft.

PAGE 12

Apply the ideas about living in space and the means of power needed in space to these pictures. The pictures should be used for inquiry purposes.

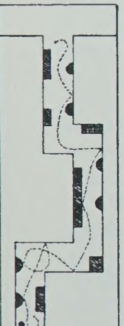
(A) Measure the craft shown against space travel.

(B) Measure the usefulness of the craft shown in environments other than space.

THE RIVER

PAGE 14

In order to understand how man has learned to measure time, distance, direction, and speed, and how his ability to measure such things has greatly affected his way of life, we need to start back with the simple river craft of ancient Egypt.



hall navigation

We can begin with an analogy. The Nile River can be likened to a long, narrow hall, with several bends and windows along the walls. If a student is blindfolded, he will soon learn, after a few trips up and down the hall, where the bends are, where the obstacles are, and where the markings are along the walls. Having "navigated" it a few times, he will soon travel up and down with confidence.

The river-man on the Nile would learn to travel the river in the same way. He would remember the obstacles in the river and know by sight every object along its banks. For him navigation was not a science; he came to know the river just as the student knows the hall.

The major problem in river travel is not so much navigation as finding a suitable craft. Egypt had very few materials for boat-building. A study of the evidence on pages 16-19 makes this clear. The evidence suggests (a) the variety of materials used for boat-building and (b) the limitations of these materials in building a boat.

Lack of suitable timber meant that these boats had no ribs and no keel. They were held together by ropes and trusses – the hog-line going length-wise pulled up the bow and stern; the trusses going cross-wise held up the sides of the hull.

Notice that, although boats were now made largely of wood, the style has the old flower pattern reminiscent of the first boats made from water plants such as the papyrus reed.

PAGES 19 – 20 Questions

1. The evidence on pages 16-19 suggests that the boat is built from local materials. The acacia tree (page 18) is small and gnarled and this explains why the pieces of wood are short and of various shapes. The relationship of the plant on page 18 to the note on page 19 to the materials on page 16 reinforces the idea of a boat's relationship to its surroundings.

2. Students can advance the argument that to build a boat from all these bits and pieces requires great skill in carpentry and engineering. There is sufficient evidence to support the argument.

3. The high bow and single mast look familiar. But there are no paddles. There appears to be a *keel* and the *hull* is made of solid timbers. The most obvious change is in the triangular sail. The advantages of this sail over the old square sail should be examined, especially since there are no longer paddles. Notice that the yardarm to which the sail is attached consists of two poles spliced together, as was the practice in ancient days.

4. If students have studied the Nile River (see *Gifts of the Nile*), they will realize that the shoreline of the river varies considerably, depending on the season. If permanent docks were constructed, therefore, they would be flooded or submerged by the river.

5. The high, overhanging bow allows the ship to run aground and the passengers to jump off without getting wet.

6. The two diagrams symbolize the means of travel on the river. When going against the current (upstream) sail power is necessary. When going downstream and against the wind, the sail is lowered and the current (with the help of paddles) moves the boat.

7. Similarities are not in fact great, but that is for the student to determine.

(A) Both craft are made from the raw materials at hand and both are skilfully constructed.

(B) Like the Egyptian craft, the canoe is gummed together from pieces of wood (or bark).

(C) Like the Egyptian craft, the canoe has a high bow and stern and is powered by pad-

dles. Occasionally a sail is used. The rudder is essentially the stern paddle.

(D) Like the Egyptian craft, the canoe is rather small and suitable only for lake and river travel. As a means of transport it cannot travel non-stop for great distances and must put ashore for the night, if only to rest the crew. Its cargo capacity is extremely limited.

The story on pages 22-26 describes the operation and navigation of the river boat. Students may wonder why the poem on page 26 does not rhyme or have a rhythm useful for paddling. The difficulties of translation provide one answer. It is also possible that the Egyptian was able to recognize a different cadence or rhythm from that which we are used to.

PAGE 27 Questions

1. The one piece of equipment we see being used is the *sounding* weight. River currents caused the bed of the river to shift so that the sailor could never memorize the channel. Consequently, he had frequently to measure the depth of the water.

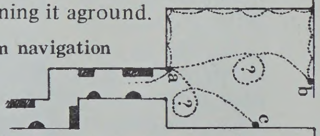
2. Charts were unnecessary because, as in the hall analogy, the sailor soon became familiar with all the river's landmarks.

4-7. The analogy of the car invites the student to see how rough calculations of speed are possible without benefit of a measuring tool (speedometer). By gauging the movement of the car in relation to the passage of the land, or telephone poles, or bushes, the motorist can judge his speed. Similarly, the sound of the engine or the tires is similar to the sound of the water against the ship's hull. Such sounds help in estimating speed.

8. While it is being loaded, it is unwise to rest the boat on the beach or river bottom, since the added weight of the cargo will make freeing the boat very difficult. Once the boat is loaded, there is no problem running it aground.

THE SEA

room navigation



PAGE 28

We can again benefit by using analogy. This time a blindfolded student is led into a room representing the sea. If he is told to navigate from Point A to point B or C, he will no doubt follow the wall, as he was accustomed to doing in the hall. But the length of the walls and the great number of obstacles will make it impossible for him to memorize the route and all its landmarks. In this case, moreover, following the wall is not the shortest way to reach point B. If we could somehow safely navigate *across* the room, we could save a lot of time.

On the chart on page 28 we see the Mediterranean Sea (our room), and at the bottom, for comparative purposes, the Nile River (our hall). First let us consider the craft we might use to sail in the sea. The "flow chart" on page 29 illustrates the problem. It shows the river craft, the things needing consideration in rebuilding the craft, and the relationship of these considerations to the new "space".

We can, for instance, consider the materials of which the Egyptian craft is made and whether these are adequate for conditions in the open sea. Gale winds together with wide expanses of open water will create storms and stresses that would not occur on the river. A much stouter material, probably planks, and a stronger mast are necessary. (This argument can be challenged in the light of the Ra II voyage discussed on page 19.)

In considering craft construction, we would probably want a ship reinforced with a keel and with ribs. To avoid being swamped by higher waves we would want higher sides. For longer distances we would want a deck and probably a cabin. In considering size, we would want a much larger craft, if only to carry more crew and more cargo on longer voyages.

In considering power for the boat, we note that the Nile system of wind upstream and current downstream is no longer applicable. The North-East wind still blows, but there is no strong river current for the return. We cannot wait half the year for winter gales, and in any case gale winds create storms. Winter voyages are therefore not recommended. We can suggest two things. First, exchange the square sail for a triangle sail (such as that on the modern river boat seen on page 19). This type of sail will let us travel up wind. Secondly, keep the paddles. (Since we have already decided on higher sides, we might prefer oars to paddles.)

PAGES 30-31

All of these innovations, although excellent, will not necessarily be adopted by our new craft, the *Kyrenia.* The questions on pages 30 and 31 are fairly easy to solve, although one or two points must be kept in mind. Note that the cradles in Step 1 are not part of the ship. The actual ribs of the ship are used to reinforce the sides and are nailed into position after the sides have been built.

PAGE 33 Questions.

1. The style is still similar to the rivercraft, especially in the high bow and stern. Although there is a partial deck and cabin, most of the ship is open. The rudder is still a large paddle

tied to the side of the stern. The square sail is preserved.

2(a) A crew of rowers consumes too much of the profits.

(b) The problem of using a square sail on the open sea has already been discussed.

(c) Since the square sail is most effective with the wind at the rear, a high stern is needed to prevent waves from coming in over the stern.

(d) The rings can be seen on the sails, similar to curtain rings. The use of rings allows sail movement. This flexibility saves the sail from being torn under wind stress.

3–4. The *Kyrenia* is so heavy that if she were run up on the beach, it might be very difficult to work her free. Docks are a necessity for boats of this size (see picture page 32). In the case of the Mediterranean Sea, there is no rise or fall from flood or tide.

DID YOU KNOW?

Not all amphorae had pointed bases, although this kind was common. The roundness of the amphorae allows for easy rolling into boats. In the boat they fit the curve of the hull. When covered with sand to prevent movement, they act as ballast.

As suggested in our analogy, following any direct route between points A and B, even simply crossing a room blindfolded, presents problems in navigation. In studying the problems of building a new ship, the class is by now familiar with the concepts involved in the page 34 diagram. The problem presented by each of these concepts was minimal in navigating the Nile. On the open sea, however, most of these offer complex problems in navigation that cannot be handled simply by watching the shore or following the current. The class may have hypothesized about currents in the sea being similar to the current in the river, but most "currents" in the Mediterranean are slow-moving compared to a river current. Similarly, depth is more difficult to measure in the sea than in the river. Sounding is not always possible in this deeper water, with the result that sudden shallows or rocks present a real danger. The problems of distance also increase, since on a voyage of several days beyond sight of land, it is easy to get lost. The direction of travel and the distance travelled in that direction must be measured.

One means of keeping track of things such as distance and rocks is seen on page 35. The student can see that our previous charts showed only the eastern part of the sea. The Carta Pisana tries to give accurate coastline information and accurate distances between various points. The rhumb lines are the means by which the navigator plots his course.

Since the Carta Pisana is not detailed, the Log Book (page 36) and the Harbour Map (page 37) are very important. They provide detailed accounts of the shore and the port, although they do not provide a guide to any sailor travelling beyond the sight of land.

PAGE 36 Questions

1. The Log Book is written in Italian and suggests that by the 13th century Italy had become a major sea power. It could be argued that power has shifted from the Greeks and Phoenicians to the Italians.

2. The name "portolana" suggests a "port map", and this is essentially what it described. Literally, the word "porto" means "carry," descriptive of the fact that these maps were easily rolled up and carried by the navigator on his voyages.

Pages 38-40 deal with developments in navigation equipment. The first instrument we see is the compass (page 39). It measures direction. Below the compass, two pieces of equipment are in evidence: a cork and a sand glass. These are used to measure speed in the following way. A sailor drops the cork off the bow, and at the same instant a sailor in the stern tips the sand glass. The latter measures the time it takes the ship to pass the cork. Suppose it takes 30 seconds and that the Kyrenia's length is 50 feet. That means the ship is moving 100 feet every minute, or 6,000 feet every hour. The speed of the Kyrenia in this case would be 1.13 miles per hour.

The instruments at the top of page 40 are the same. The equations suggest that if we measure speed together with direction, we can determine distance. Once we have calculated distance, the instruments in the middle of page 40 can be used to measure and plot distances on the chart.

5. The student is asked to measure the space and the time it might take to make a journey over the sea (a few days at most). Although our instruments will not give us precise measurements, they will be good enough on short trips to allow us to make a land-fall within a few miles of where we intended.

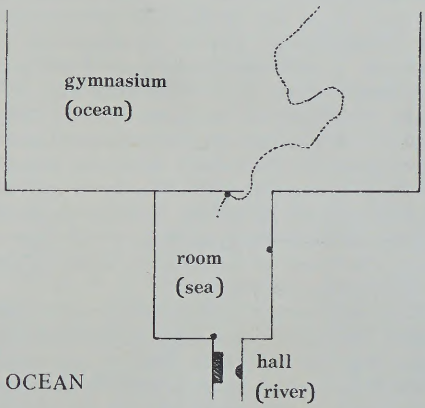
PAGE 41

If your students were disappointed that the Kyrenia did not have oars, let them take heart. Although most cargo boats were of the Kyrenia type, biremes and triremes were used for trade. The trireme has low sides so that it can be rowed,

and much of the interior is filled by the rowers. It is not economical to operate, unless speed is important or the winds and currents on the route make normal progress difficult.

The Greeks used this type of ship for war. It is very fast, can be easily manoeuvred, and with a metal beak on the bow can ram and sink the enemy ship. The ship is not, however, usable in rough water, because of the low sides and because wave action would upset the timing of the rowers. When rowers sit at two levels, the ship is called a bireme; at three levels, a trireme. The ship illustrated on page 41 is a trireme. The man at the rear is steering, while the man in the bow is chanting the time for the rowers.

The two statements at the bottom of page 43 can be examined in relation to the map on page 42. Good wall maps of the Greek and Phoenician Empires show even more clearly the opportunities and advantages of "sea-power". This idea can be reinforced with maps of the later Roman Empire. The second statement suggests that where two or more empires develop, there will eventually be a collision leading to a major war. The most notable area of collision is Sicily. Eventually, this collision developed into the Punic Wars.



THE OCEAN

PAGE 44

The DID YOU KNOW? section will help students understand why the map was drawn in this way.

Question 5. The map gives the Earth a disk-shaped appearance, and to the uninformed this would suggest the chance of falling off the edge of a flat world. For this reason, the King of Carthage would have trouble getting sailors to sail out of the Mediterranean to the West and around the disk to Issedones. This map was made from information provided by the Greek Hecateaus about 500 B.C. When the students examine the map on page 46, the Hereford map, they should recall this earlier one and ask questions of comparison.

PAGE 45

1. Believing the world to be a sphere, Ptolemy has shown a sector from the sphere. He has used lines of latitude and longitude based on solar observations and mathematics. The equator is central to understanding his map.

Ptolemy's world would be smaller than the real world, measuring 18,000 miles at the circumference rather than 25,000. Students can measure the length of the Mediterranean Sea here, then apply their findings to a modern map and to the map of Ptolemy in the Ancient Atlas section.

Ptolemy was the first to show North at the top of the map as a standard practice. Usually East had been placed at the top.

PAGE 46

Note how simplified the map is. Students should be asked to explain the religious conventions used and the lack of scientific measurements. They should compare the accuracy of this map to that of Ptolemy's map and comment on the regression over 1300 to 1400 years. Notice that Asia is at the top, indicating that the map is again oriented, that is, East is the prime direction. This was church-approved. (According to the church, the earth was flat, surrounded by an endless sea.)

PAGE 47 Questions

1. While Asia appears to have much that is needed or desired in Europe, the reverse does not appear to be true. As a result, the Europeans traded by paying gold for goods, rather than by the barter system they might have preferred.
2. It is suggested that the teacher locate London and Hangchow for the students.

The map at the bottom of the page indicates links between West and East. Ships sailing from Venice and Genoa to the eastern end of the Mediterranean obtain goods from caravans. The ships return to their home ports, from which the goods are carried throughout Western Europe. Costs are high because of much handling, difficult transport routes, tariffs, theft and many monopolies by feudal barons.

PAGE 48

Students should be encouraged to compare the map of Ptolemy with that of Fra Mauro (page 48). (Ptolemy's map is still superior in many ways, despite the centuries that had elapsed.) The question could be asked, "what would have happened to much of the history of the late 1400's and the 1500's if Prince Henry had believed Ptolemy?"

PAGE 52 Questions

1,2. Note the absence of scale on this map.

The student should be encouraged to devise a scale. He might use the Mediterranean as reference, which was well known. Another reference that might be used is the letter on page 51. Notice that the influence of Ptolemy is still felt in the "small-earth theory".

4. The class should be asked to design a new type of ship to sail west across the Atlantic, before the diagrams on page 53 are studied.

PAGE 53

In examining and explaining the change from the Kyrenia to the Santa Maria, reference must be made to such things as a "new space," longer distances, and a different environment. To overcome these problems, new sails, larger ships, and more living space had to be provided. The sails in the Santa Maria are higher, enabling them to catch stronger breezes, thus making the ship move faster. The change in sails from just one great square-rigged sail on the main mast to a fore and aft rig allows the captain to steer his ship closer to the wind. (This means he can sail almost straight into the wind, necessitating fewer tacks upwind.) The great number of sails on the Santa Maria enables the captain to let out sail when the breezes are light, and to furl sail when stiff breezes blow. Much extra rigging is needed to accomplish all of these changes. With better rigging and more pulleys and capstans, the larger ships could be operated with smaller crews. This was a vital factor, for ships carrying fewer men could carry heavier cargoes more cheaply or could be laden with additional provisions and fresh water. They could therefore sail longer and on more adventurous trips.

The need for a larger ship was obvious to Columbus. He would be at sea for a long time, and would therefore need many supplies, water and food, as well as shelter for the crew. The larger, sturdier ship would also protect against the bad weather often encountered in an open ocean.

Students should refer to page 31 and reread the section on how the hull of the Kyrenia was built. They should raise questions about long voyages with perhaps rough seas, strong winds and severe storms, and hypothesize about their effect on this type of hull. What change in the Santa Maria is desirable?

Finally, a much more efficient way of steering is provided in the Santa Maria. A stern rudder has been fitted to replace the ancient steering oars.

The diagram at the bottom of page 53 should be used to have students solve a problem. Things to keep in mind regarding this method of determining speed are:

(A) The sand glass operates for from 4 to 7 minutes.

(B) The knots are evenly spaced.

(C) The wood carries the rope astern of the ship.

(D) As the ship varies its speed, the knotted rope will run out more or less quickly.

Students could be asked to consider the accuracy of this method. What conditions would make it less accurate than usual? (Currents? Rough seas? A pitching ship?) Consider why.

PAGE 54

"Astrolabe" (astron – a star, lambano – I take) was the name given by the Greeks to any circular instrument having one or more graduated circles. Hung perpendicular to the deck (by one man holding it as steady as he could) a sight would be taken along the moving arm, which was moved to point at the star or planet. The angle of rotation between the horizon and the heavenly body was used to help preserve a certain course at sea.

If the captain wished to secure his latitude at sea, he took a sight on the North Star. The reading he obtained was his latitude north of the Equator. This method did not apply south of the Equator, since the North Star could not be seen from there.

QUESTIONS

6. Adjustment is necessary because of the apparent movement of the sun north and south of the equator. (Question 7 illustrates this point.)

7. (a) ____________ Equator 0°

____________ Tropic of Capricorn 23½°S.
Sun over Tropic on Dec. 21 (23½°S.-20° = 3½°S.)

Reading is 20°N. of sun.
Ship must be at 3½°S.

(b) ____________ Tropic of Cancer 23½°N.
Sun over tropic June 21

Reading is 12° N. of sun.
Ship must be at 23½°N. + 12° = 35½°N.

(c) ____________ 23°N. Reading
____________ Sun over Equator on Sept. 21
Ship is at 23°N.

8. Below the Equator, where the North Star is invisible, navigators had to compute their latitude by measuring the height, in degrees, of the sun above the horizon at noon. This implies that they had information about the positions of the sun in

relation to the celestial horizon. Tables provided mariners with this information. During the day, north of the Equator, the sun would also be used; thus the need for tables of declination.

PAGE 55 Questions

3. Since Columbus could not measure longitude accurately, and because he did not want to sail by Japan, he thought it best to go south to 25° – 20° N, then sail along the parallel, which he could determine.

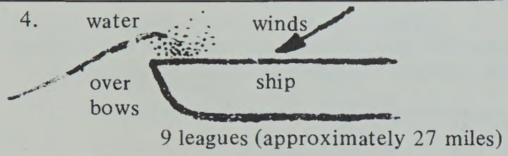
4. The above describes "parallel sailing" and explains why it could be followed.

5. Without the ability to determine longitude he could not accurately determine his position at sea.

PAGES 56-7 Questions

3. Sediment carried down by the Saltes River is dropped at the mouth of the river as the water slows upon entering a larger body of water. Tides tend to sweep into the mouth of the river and pile this sediment up in the form of a bar.

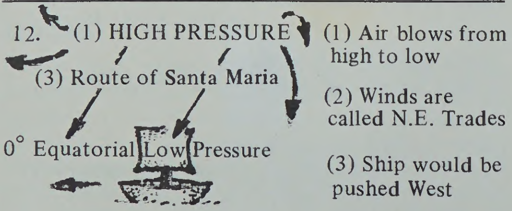
4.



5. The ocean current is a flow of water, horizontical or vertical, in response to the drag of winds over the sea surface or to unequal forces caused by differences in water densities. (See Strahler, **The Earth Sciences**, 2nd ed. (New York: Harper & Row, 1971), page 297.)

6. Within the broad current, eddies and drifts occur which would baffle the ships.

12.



13. The diagram above on page 57 should be used. The high pressure area shown is a migratory system passing through the area where the three ships are sailing. As the ships of Columbus approach this moving high pressure cell, the winds they will experience will be from the West for a short time.

PAGE 61

The radar equipment enables the navigator to see in foul weather, in darkness, and to see further than the naked eye, even with binoculars. It sees all things in a sweep of 360° and produces a pattern on a screen. It can operate continuously if needed.

The relationship between time and distance gives us speed. The distance covered during any time interval can be read as speed.

Sonar does the same job as radar (described above), except that it operates under water.

MAN IN HIS WORLD
James Forrester, Co-ordinating Editor

The Navigators Teachers' Guide

Authors: James Forrester
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